PROC. ENTOMOL. SOC. WASH.
108(3), 2006, pp. 575–582

THE BIOLOGY OF *CHIONODES HIBISCELLA* (BUSCK) (LEPIDOPTERA: GELECHIIDAE), WITH DESCRIPTIONS OF THE IMMATURE STAGES

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Abstract.—Observations are presented on the life history of *Chionodes hibiscella* (Busck) (Lepidoptera: Gelechiidae) on *Hibiscus moscheutos* L. (Malvaceae) in nontidal freshwater wetlands and intertidal habitats along the Chesapeake Bay in Maryland. In the summer, early instar larvae of this bivoltine species are leaf-tiers in young terminal leaves; later instars construct leaf rolls from mature leaves. In the fall, larvae from the second brood feed on the seeds of mature fruits and overwinter in the dried fruit capsule. The morphology of the larva and pupa is illustrated with images from digital day-light photography, scanning electron microscopy, and line drawings. Chaetotaxy of the larva, mouthparts and associated sensilla, claws of the thoracic legs, prolegs of the abdomen, and the anal fork are described.

Key Words: Gelechiidae, *Hibiscus*, larval behavior, Malvaceae, morphology, pupa

Species of *Chionodes* Hübner (Gelechiidae) are found throughout the Holarctic and Neotropical regions. However, most of the nearly 200 species are known from North America north of Mexico. Host plant data are available for 79 species, but little is known about the complete life histories and feeding habits of most species (Hodges 1999). We describe the immature stages of *Chionodes hibiscella* (Busck) and add to the existing knowledge of its natural history and life cycle.

Chionodes hibiscella is related to 65 other species recognized as the *lugubrella* group (Hodges 1999). Males of the group share a hindwing with slender sex scales on the dorsal, basomedial surface; a vinculum that is narrow to broadly U-shaped and a lobe arising from the posterolateral surface; and sternum 8 with a medial rectangular extension, the surface of which has a sclerotized, often obliquely lined zone anteromesally. Females share an antrum lacking a posteriorly directed extension of the ventral wall; apophysis anterioris arising dorsally; and usually with a sclerotized rim on tergum 8 with an extremely short free part. Larvae in the *lugubrella* group have been reared from several plant families including Asteraceae, Betulaceae, Cladoceraceae, Fabaceae, Malvaceae, Rhamnaceae, Rosaceae, Selaginellaceae, and Sterculiaceae.

Within the *lugubrella* group, Hodges (1999) recognized 11 species complexes. The *hibiscella* complex contains six species, one of which is *Chionodes hibiscella*. Members of this complex are characterized by the following: valva highly sclerotized and less than half the length of the tegumen; saccular lobe reduced and/or represented by a patch of setae; tegumen with anterior margin deeply emarginate; vinculum short; uncus with posterior margin smooth; sternum 8 with anteromesial margin tuning-fork shaped; an aedeagus lacking cornuti; ductus bursae short; and corpus bursae with two zones of sclerotization. All Nearctic species of the *hibiscella* complex are suspected or confirmed herbivores of Malvaceae. Of these species, *C. hibiscella* has received the most study and is known to feed on *Hibiscus* L. and *Kosteletzkya* Presl. (Hodges 1999).

MATERIALS AND METHODS

Observations on the natural history of *Chinodes hibiscella* (Fig. 1) were made as part of a broader study of herbivory and seed predation of *Hibiscus moscheutos* L. (Malvaceae) (Figs. 2–3) at the Smithsonian Environmental Research Center (SERC), located along the Rhode River subestuary of the Chesapeake Bay (38°53′N, 76°33′W) near Edgewater, Maryland, USA. Plants of *H. moscheutos* were monitored in 14–22 sites across three different habitat types: nontidal freshwater wetlands, intertidal habitats with frequent flooding and seasonally varying salinity (Fig. 2), and high marsh intertidal habitats with higher salinity and less frequent flooding.

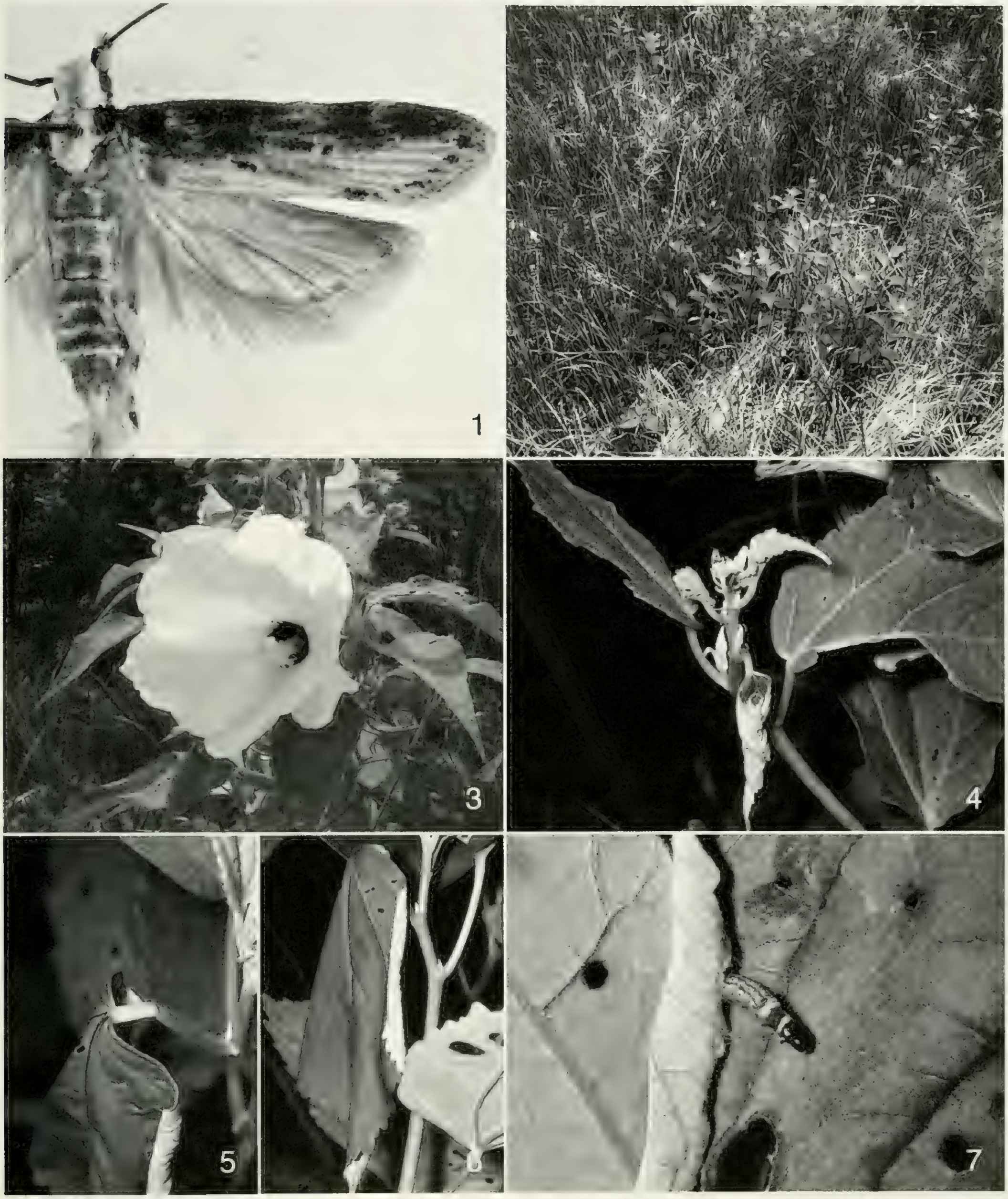
Marked plants were examined for herbivore damage in June of 2000–2002. Larval specimens of *Chionodes hibiscella* were collected from leaves of *Hibiscus moscheutos* during June 2002. All larvae were either boiled in H_2O and preserved in 70% EtOH, retained until pupation for preservation and study of the pupa, or maintained in the laboratory for adult emergence.

During the period from August through October, fruits of *Hibiscus moscheutos* were collected as they matured and dehisced on marked shoots. Fruits were stored individually in Ziploc® bags, glassine envelopes, or small plastic cups and later dissected and examined for evidence of seed predators. Live or dead larvae found in fruits were preserved in 70% EtOH. For SEM study, larvae and pupae were cleaned in 10% alcohol with a camel's hair brush and subsequently dehydrated in increasing concentrations of alcohol to absolute alcohol. After dehydration, specimens were critical point dried using a Tousimis critical point dryer, mounted on SEM stubs, and coated with gold-palladium (40/60%), using a Cressington sputter coater. The ultrastructure of the larva and pupa was studied with an Amray 1810 scanning electron microscope at an accelerating voltage of 10 kV.

Gross morphological observations and measurements of the larva and pupa were made using a dissecting microscope (reflected light) with a calibrated micrometer. The Methuen Handbook of Colour (Kornerup and Wanscher 1978) was used as a color standard. All voucher specimens from this study are deposited in National Museum of Natural History, Smithsonian Institution, Washington, DC.

BIOLOGY

The feeding behavior of *Chionodes hibiscella* is easily distinguished from that of other *Hibiscus* herbivores. Larvae or evidence of their presence were found in all three *Hibiscus* habitat types at SERC. Observations of *C. hibiscella* activity on *Hibiscus moscheutos* shoots in mid- to late-June were usually of leaves rolled from one or both edges that housed the larva as it fed (Figs. 6–7). Our observations generally agree with those of Busck (1903), Heinrich (1921), Weiss and Dickerson (1919), and Cahoon and Stevenson (1986): the larva cuts a small notch in the petiole (Fig. 5) that causes the leaf to hang, but not to drop. Weiss and Dickerson (1919) suggested that partially severing the petiole



Figs. 1–7. Adult, habitat, host, larva, and larval behavior of *Chionodes hibiscella*. 1, Adult. 2, Wetland habitat. 3, Flower of *Hibiscus moscheutos*. 4, Petiole of *Hibiscus* leaf, showing notch cut by larva. 5, Leaf margin rolled by larva. 6, Leaf roll constructed by larva, dangling from partially severed petiole. 7, Larva repairing a previously disturbed leaf roll.

in this manner allows the larva to roll the leaf more easily as it wilts slowly and becomes more flexible. The larva eventually pupates in these leaf rolls, which wither and either remain attached to the plant (Fig. 4) or drop to the ground.

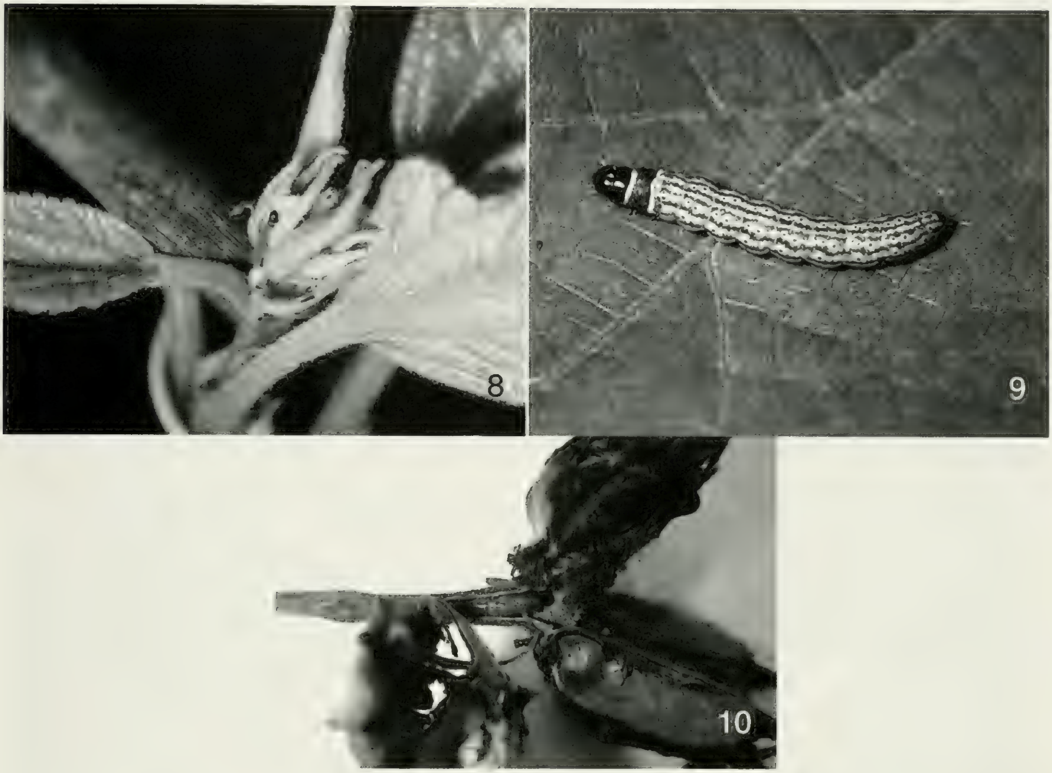
June observations also included early instar larvae, which typically were found in the cluster of young leaves at the shoot tip (Fig. 8). Sometimes larvae pulled the upper surfaces of two small young leaves (~2 cm^2 leaf area) together with silk and fed in the region between them. Larger young leaves occasionally were folded lengthwise along the midrib. Larvae also occurred in silken shelters constructed between a mature leaf and a dry young leaf that had been partially eaten at the base by younger instars.

Observations of larvae at SERC are consistent with claims that *Chionodes hibiscella* is bivoltine. Busck (1903) collected adults in May and August in the District of Columbia, and Weiss and Dickerson (1919) reported adults flying in early June and late July and into August in New Jersey, indicating two flight periods a year for *C. hibiscella*. At SERC, mature larvae collected from *Hibiscus* leaves in early June 2002 pupated several weeks later. In September and October of 2000 and 2001, late instar larvae were found in silken tubes constructed inside dry *Hibiscus* fruits. Signs of *Chionodes*' presence included large holes in the fruit wall near the base, frass inside the fruit, and damaged seeds. Larvae also were encountered in silken shelters between the calyx and the fruit, with no signs of fruit damage. Cahoon and Stevenson (1986) reported similar patterns in herbivory in *Hibiscus moschuetos* in a marsh along the Choptank River on Maryland's eastern shore, with damage to leaves occurring from early June to late July and infestation of fruits noted in October.

Larvae feeding on fruits in the fall at SERC are likely offspring of the generation observed feeding on leaves in June. Weiss and Dickerson (1919) reported that the eggs laid by adults emerging from the early summer brood hatch by the end of August and feed at the shoot tip and around the inside of the fruit. They observed in New Jersey that larvae are mature by late October, and overwinter in this stage. At SERC, mature larvae could still be found in dried fruit capsules on standing dead shoots in mid-November 2002. Often the peduncle of the fruit was hollowed out by the larva and it becomes a common site for pupation (Fig. 10). Though little examination of *Hibiscus* was conducted in winter and early spring at SERC, we have encountered pupae of *Chionodes hibiscella* in *Hibiscus* in mid-April.

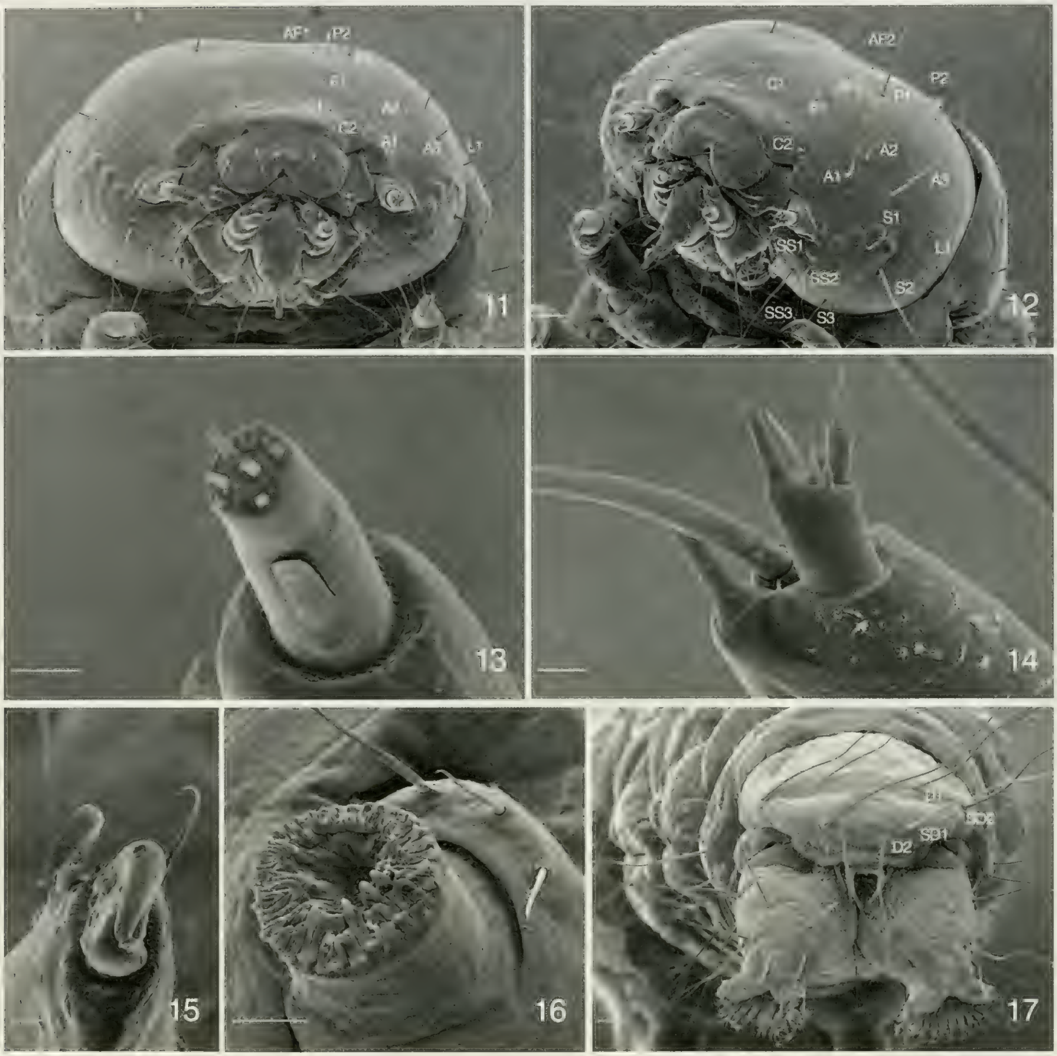
DESCRIPTIONS OF IMMATURES

Larva (Figs. 7, 9, 11–21).—Length 10.0–14.1 mm (n = 10). Body smooth, pale gray or off white with paired dorsal, subdorsal, and lateral, irregularly shaped, longitudinal, grayish-red stripes from T3–A10 (Figs. 7, 9, 18–19, 21); T1–T2 grayish red (grayish-red pigmentation fades rapidly in specimens preserved in EtOH); sclerites of thoracic legs darkly pigmented, claw juxtaposed to a flattened, downcurved seta (Fig. 15); all pinacula brown centrally, gradually becoming paler to outer margin; anal shield pale brownish yellow with small, darker pigmented spots on surface; T1 with shield dark brown along posterolateral margin, gradually becoming paler to anterior margin; head capsule dark brown except for 2 large, dorsolateral, amber spots on epicranium from outer margin of adfrontal sclerite to posterolateral area of the epicranial notch, gradually darkening to the genal area. Head (Figs. 11–12): Hypognathous; adfrontal sclerites narrow, gradually widening from lateral margins of clypeus to epicranial notch; paired AF2 near apex of frons, but not beyond, about equal in length with AF1; AF1 and AF2 slightly shorter than F1; C2 and C1 about equal in length; F1 equidistant to C2 as C2 is to C1; labrum with 6 setae, 2 mesial, 2 near middle of lateral lobe, and 2 near outer margin of lateral lobe; outer labral setae about equal in length, about twice length of mesial setae; other setae of



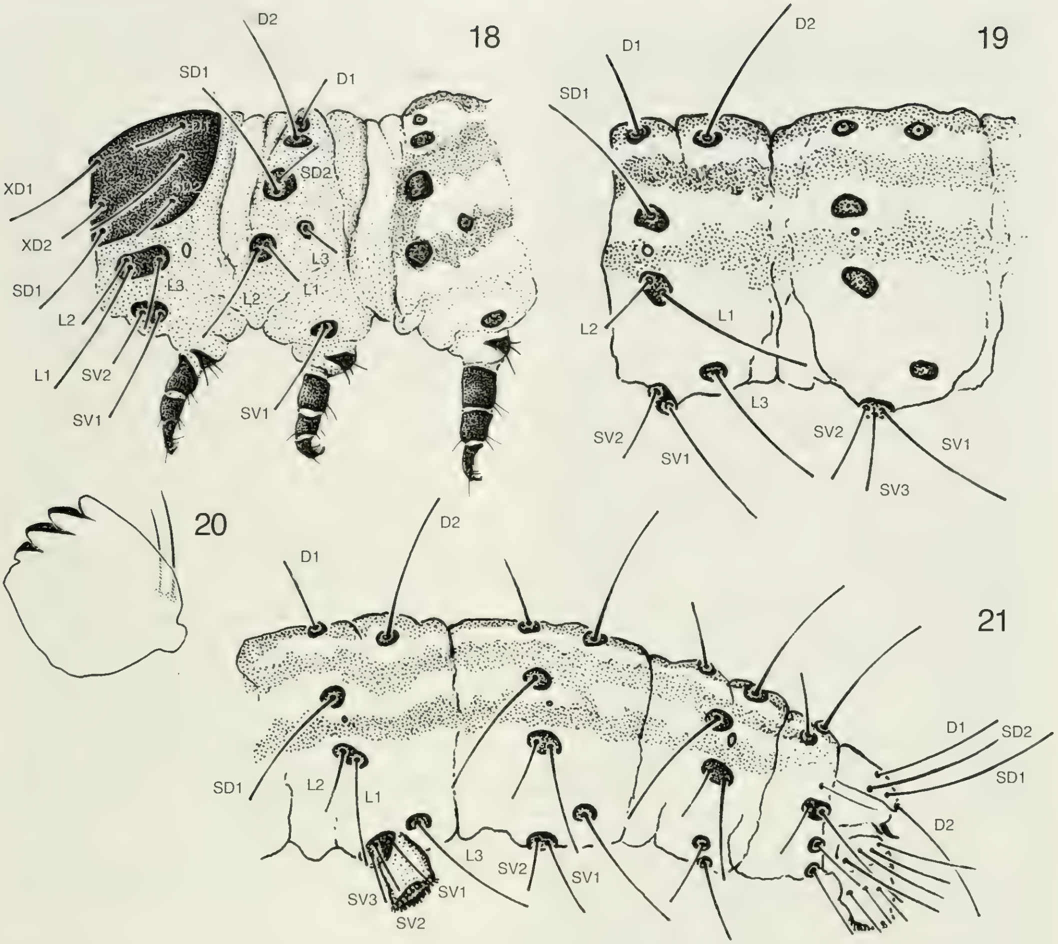
Figs. 8–10. Larva and pupa of *Chionodes hibiscella*. 8, Early instar among terminal leaves of host (see arrow). 9, Mature larva. 10, Pupation site within fruit.

head capsule are illustrated in Figs. 11–12. Mandibles (Fig. 20) slightly asymmetrical, quadridentate, and with pair of subequal setae on outer surface; maxilla and antenna with sensilla types and arrangement as illustrated (Figs. 13–14); six stemmata in a C-shaped arrangement; stemmata III and IV slightly approximate. Prothorax (Fig. 18): SD1 and D2 about equal in length, longest setae on shield, XD1 slightly shorter; SD1 in straight line with XD2 and XD1 along anterior margin; SD1 about 2.5 times longer than XD2; XD1 slightly shorter than D2; SD2, D2, and D1 in straight line; distance between XD2 and XD1 about twice distance between SD1 and XD2; SD2 and XD2 about equal in length, SD2 equidistant to SD1 and XD2; D2 about 2.5–3.0 times longer than XD2, D2 equidistant to XD2 and XD1; L-group pinaculum trisetose, L1 closer to L2 than to L3, and about 2 times longer than L2 or L3; L2 and L3 about equal in length; L1 slightly longer than SV1, SV1 about twice as long as SV2; coxae about ⅓ distance apart as distance between coxae on T2–T3 (not illustrated); V1's about 1/3 distance apart as distance between V1's on T2–T3 (not illustrated). Meso- and metathorax (Fig. 18): D2 and D1 on separate pinacula, D2 about 2.5–3.0 times longer than D1; SD1 and SD2 on same pinaculum, SD1 about 2.5–3.0 times longer than SD2; D1, SD1, SD2, and D2 in straight; L2 about twice length of L1, L1 slightly longer than L3; SV1 slightly posteriorad to L3; SV1 slightly shorter than L2. Abdomen (Figs. 16–17, 19, 21): A1–A2 (Fig. 19), with D2 about 2 times longer than D1; SD1 and D2 about equal in



Figs. 11–17. Larva of *Chionodes hibiscella*. 11–12, Chaetotaxy of head. Scale = 100 µm. 13, Maxillary palpus. Scale = 10 µm. 14, Antenna. Scale = 10 µm. 15, Claw of thoracic leg, with adjacent flattened and downcurved seta. Scale = 10 µm. 16, Abdominal proleg. Scale = 100 µm. 17, Anal shield and anal fork. Scale = 100 µm.

size; SD1 in vertical line with D1; SD1 slightly posteriorad spiracle; L1 about 3 times longer than L2, slightly posteriorad spiracle; L2 in line with or slightly anterior spiracle; L3 longer than L2, and in line with or slightly posteriorad to D2; SV-group bisetose on A1, SV1 about 2 times longer than SV2; SV-group trisetose on A2, SV1 about twice lengths of SV3 and SV2. A3–A6 with SD1 slightly anteriorad spiracle; one tonofibrillary platelet dorsoposterior to SD1 and near ventral margin of subdorsal longitudinal stripe; SV-group trisetose on proleg; crochets biordinal except, uniordinal and weak laterally (Fig. 16); V1's slightly farther apart than on A1–A2 and A7–A8. A7 (Fig. 21), with SV-group bisetose, SV1 slightly longer than SV2. A8 (Fig. 21), with SV-group unisetose, SV1 slightly longer than L3; L3 slightly posteriorad to L1, and in line with SV1.

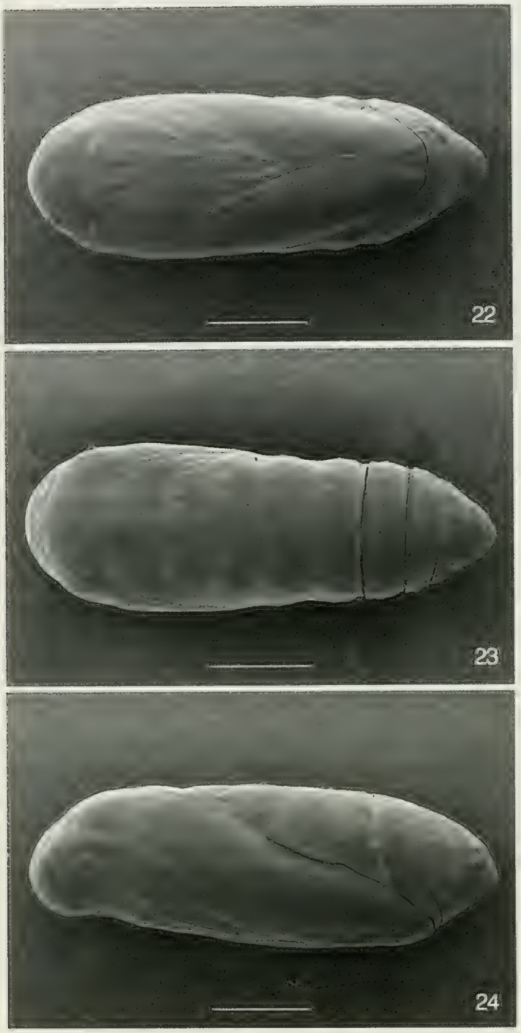


Figs. 18–21. Chaetotaxy of larva of *Chionodes hibiscella*. 18, Thorax. 19, Abdominal segments 1–2. 20, Mandible. 21, Abdominal segments 6–10.

A9 (Fig. 21), with D2 about twice length of D1, D1 slightly anteriorad to D2; SD1 hairlike, and in line with D1; SD1 about equal in length to D1; L1 about twice as long as L2, and in line with L3 and SV1. A10 with anal plate (Figs. 17, 21), with SD2, D1, and D2 about equal in lengths, SD1 slightly longer; D1 slightly anteriorad to SD1, and in line with SD2; D2's decumbent; anal fork with 2 pairs of sickle-shaped furcae, mesial pair about twice as long as lateral pair.

Pupa (Figs. 10, 22-24).—Length: 4.0–5.4 mm (n = 10). Body smooth; femur of foreleg exposed as a short narrow sclerite; tip of hindleg exposed between slightly divergent apical portion of antenna; terminal six abdominal segments pivoting as a unit.

Remarks.—Larvae for two species of *Chionodes*, *C. arenella* (Forbes) and *C. trichostola* (Meyrick), have been illustrated previously by Hodges (1999). Both *Chionodes hibiscella* and *C. trichostola* possess a similar anal comb and SD1 on A9 is hairlike, whereas in *C. arenella*, the anal comb is absent and SD1 on A9 is setiform. *Chionodes hibiscella* appears to differ from *C. trichostola* by having D1, SD2, and XD2 equal in



Figs. 22–24. Pupa of *Chionodes hibiscella*. 22, Ventral view. 23, Dorsal view. 24, Lateral view. Line scale = 1 mm.

lengths on the prothoracic shield, and L3 is near equal in length with L2 on the prothorax.

ACKNOWLEDGMENTS

We thank C. Feller, J. O'Neill, and D. Whigham of the Smithsonian Environmental Research Center, Edgewater, MD, for support and advice. Research by JLA was supported in part by a Smithsonian Institution Postdoctoral Fellowship.

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